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Piezoelectric actuation of graphene-based polar structures: frequency and geometry effects

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Ferroelectric materials based on lead zirconate titanate (PZT) are widely used in sensors and actuators because of their strong piezoelectric activity and compact design. However, their application is limited because of high processing temperature, brittleness, lack of conformal deposition and, more importantly, limited possibility to be integrated with micro- and nano electromechanical systems (MEMS and NEMS). Recent studies on piezoelectricity in 2D materials have demonstrated their great potential in these applications, essentially due to their flexibility and integrability with MEMS and NEMS [1]. In this work, we deposited a few layer graphene (FLG) on amorphous Si_3N_4 membranes and studied their electromechanical response by sensitive laser interferometry and rigorous FEM calculations. Modal analysis by FEM and comparison with experimental results show that the driving force for piezoelectric-like response can be the polar interface layer formed between residual oxygen in Si_3N_4 and FLG. The response reaches about 14 nm at resonance and could be further enhanced by adjusting geometry of the device. These phenomena are fully consistent with the earlier Piezoresponse Force Microscopy (PFM) results on free-standing graphene on SiO_2 grating substrates [2] and open up an avenue for using graphene-based structure in MEMS, NEMS and microenergy harvesting applications [3].

The work was financially supported by the Russian Foundation for Basic Research within the project 16-29-14050 ofr. The equipment of the Ural Center for Shared Use "Modern nanotechnology" of UrFU was used.

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